SHORT-WAVELENGTH OBSERVATIONS OF HH-2H and HH-24A

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ABSTRACT

There still remains some debate about the exact origin of the very blue optical and ultraviolet continuum in Herbig-Haro objects. We Believe that there is reasonably good evidence for a two-photon continuum in HH-2H. It has recently been suggested that there is a significant contribution to the uv continuum from scattered light in the general Orion region. We present evidence from spatially resolved IUE spectra which indicate the continuum and emission line fluxes have the same spatial distribution. A very low ultraviolet extinction is indicated based upon an enhanced two-photon origin for the uv continuum. A recent observation of HH-24A shows an interesting absence of high excitation emission lines and a weak continuum.

INTRODUCTION

Ultraviolet observations of Herbig-Haro objects have lead to several new insights, as well as new enigmas. The initial uv observations of HH-1 (Ortolani and D'Odorico 1980; Bohm, Bohm-Vitense and Brugel 1981) presented two interesting problems - (1) the continuum seemed to increase monotonically to shorter wavelengths out to 1216A; (2) the uv line spectrum corrected for standard IS extinction, indicated an ionization which was considerably too high to be compatible with the shock-wave parameters deduced from the optical forbidden line spectrum. This difficulty with the emission line, uv-optical incompatiblity is of course very dependent upon the reddening correction as applied in the uv where it is least understood.

It has also been discovered that the uv spectra of the low excitation objects, HH-43 and HH-47 (Schwartz 1983) are significantly different than those of HH-1 or HH-2H. These objects are characterized by a prominent continuum which has an apparent turnover at approximately 1500A indicative of enhanced two-photon radiation. In addition, there is a complete absence of high excitation uv lines (e.g. CIV 1549A; CIII] 1909A), yet surprisingly strong flourescent lines of molecular hydrogen are seen.

The first IUE observations of HH-2H were presented by Bohm-Vitense, et al. (1982) and contained two SWP spectra with a total exposure time of 560 minutes. An additional single exposure of 430 minutes was obtained (Brugel, Shull and Seab 1982) with improved signal-to-noise, which provided evidence of the two-photon nature of the uv continuum in these shock excited nebulae.

RESULTS: New observations of HH-2H

Herbig-Haro object No. 2H is the observationally brightest HH object in the ultraviolet and it has received the most observing time. We have obtained two additional spectra, thus there are now five SWP images with a total exposure time of 1750 minutes (29.1 hours). There remains some debate concerning the interpretation of the ultraviolet spectrum. The first topic of dispute is the continnum. Mundt and Witt (1983) have suggested that a large fraction (35% for the flux at 1500A) of the observed short wavelength continuum is not formed within the HH object but rather is scattered light seen in the general Orion region. One way to test this hypothesis is to compare the spatial distribution of the continuum flux with that of the emission lines, which are believed to be formed in situ. Of course, this comparison will lead to viable conclusions only if the flux in the emission lines does not fill the entire IUE aperture.

A spatial representation of the flux in the continuum was constructed by adding the uncalibrated flux from 1230-1600A in each of the 55 spatially resolved line-by line spectra and then subtracting the flux due to the known emissions in this spectral region. The CIV doublet at 1550A was used as representative of the spatial distribution for the emission line flux; the wavelength interval used was 1540-1560A. To compare these line-by-line distributions, the fluxes were scaled so that the background levels were equal. This is illustrated in figure 1. It is apparent that the spatial distribution is larger that a point source but it definitely does not fill the aperture. In addition, the continuum flux very closely follows the extent of the emission line. We conclude that the observed continuum and the emission lines are associated phenomena, and that there is no conclusive evidence for a scattered light contribution to the observed continuum.

We maintain that the best explanation for the observed uv continuum (Brugel, Shull and Seab 1983) is collisionally enhanced H^{o} two-photon emission, as theoretically suggested for the far uv (Shull 1982) and the blue continuum (Dopita, Binette and Schwartz 1982). All the available short wavelength data for HH-2H is shown in figure 2. The continuum flux has been averaged over approximately 50A wide bins and the bins have been chosen to

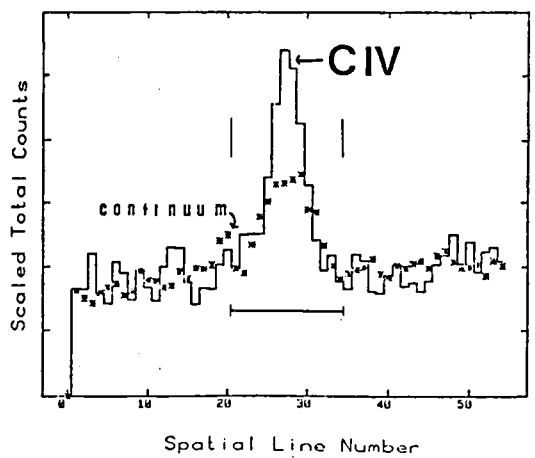

Figure 1

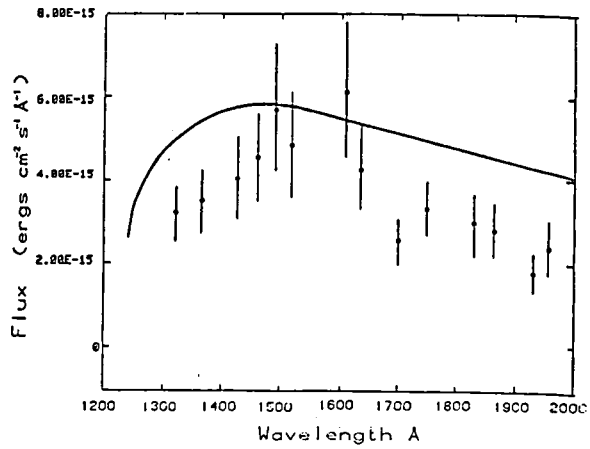

Figure 2

exclude any obvious emission lines. There still remains the "unresolved" problem of possible contributions due to weak unidentified emission lines; this problem will remain unresolved until higher dispersion observations become possible. A semi-empirical two-photon continuum is also plotted in figure 2; this curve is based upon the theoretical (Spitzer and Greenstein 1951) two-photon energy distribution normalized to the observed reddening corrected optical continuum at 4500A (Bruel, Bohm and Mannery 1982, Dopita, Binette and Schwartz 1982). Thus this curve represents an upper limit to the intrinsic ultraviolet two-photon continuum emitted by HH-2H. Since this "intrinsic" curve is only slightly greater than the observed uncorrected data, it is apparent that the degree of ultraviolet extinction is not large. Correcting the emission lines with this much smaller than average IS extinction greatly reduces the disprepancy between the uv and optical line strengths, in terms of a single set of shock parameters.

In light of the recent discovery of dramatic variabity in the uv emission line strengths of HH-1, we have re-examined all five spectra of HH-2H. We do see differences in line strengths from one spectrum to another and these differences can be as large as 50%. Nonetheless, it is not possible to ascertain any pattern to these differences or to convince oneself that they are real variations.

HH-24A

A single 540 minute SWP exposure of HH-24A was obtained on 11 Nov 1983. This object was chosen because of its uniquely large optical continuum polarization (Schmidt and Miller 1979) and its strong continuum relative to its emission lines (Brugel, Bohm and Mannery 1982). This short wavelength spectrum is shown in figure 3. With the possible exception of OIII 1661A, there is an absence of high excitation lines as is also seen in the low excitation nebulae HH-43 and HH-47. However, HH-24A does not possess a low excitation optical line spectrum. There is also no indication of an

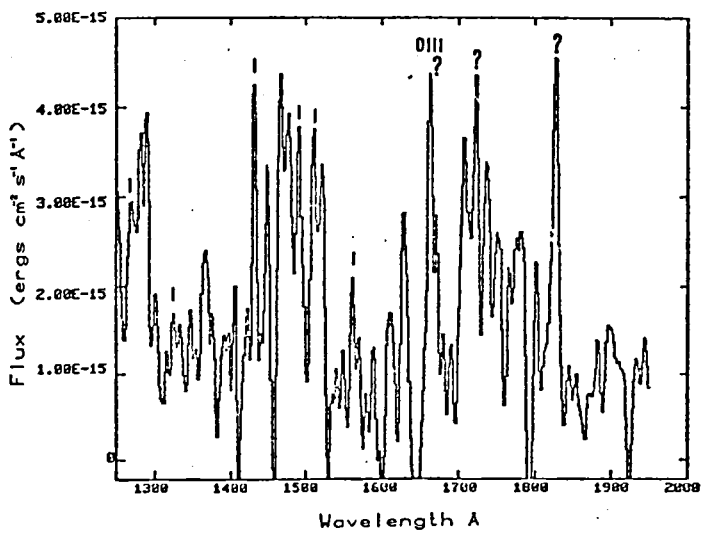

Figure 3

identifible two-photon continuum which appears prominent in HH-43 and HH-47. A few of the known H_2 lines appear to be present, there are also some lines which are not seen. The weakness of this spectrum prevents any definite assertion that molecular is definitely detected. It should be noted that this object has an E(B-V) = 0.71, as determined by the optical emission line spectrum. It is possible that the region in which the uv lines are formed is totally obscured by the large ultraviolet extinction, though these regions can be seen at longer optical wavelengths. Perhaps the observed uv radiation comes from scattering in the outter most part of the nebula. Extreme variability in the uv lines cannot be excluded as recently seen in HH-1 (Bohm, Bohm-Vitense and Brugel 1984).

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